Conservation of Momentum

IB PHYSICS | ENERGY & MOMENTUM

What is Momentum??

"Inertia in Motion"

Which has more Momentum??

20000 kg

10 m/s

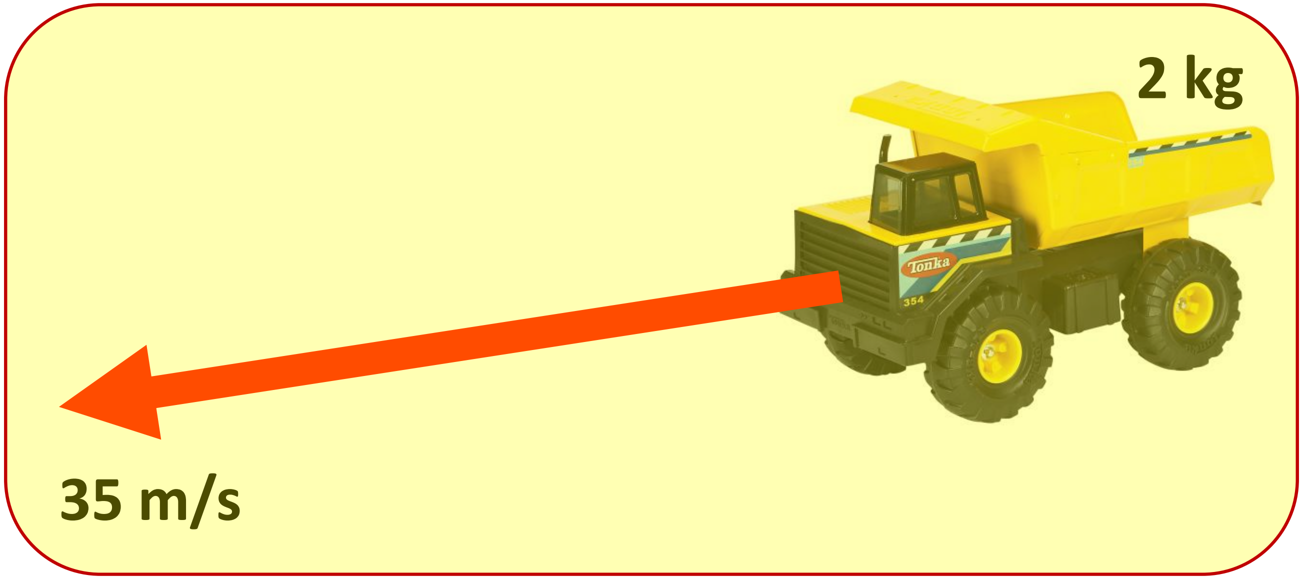
2 kg

10 m/s

Why?

More mass

Which has more Momentum??



Why?

More velocity

Momentum Equation

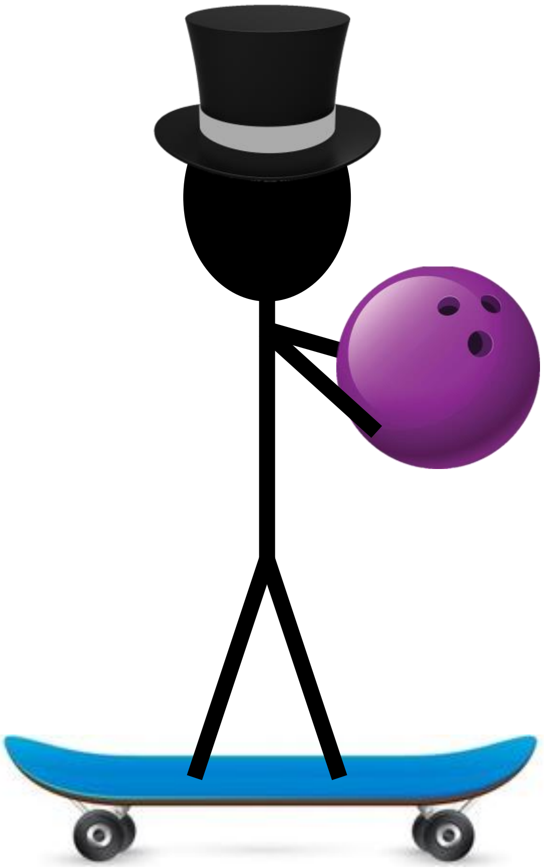
Momentum = mass × velocity

Symbols	$p = m \times v$
Units	$kg\ m\ s^{-1} = kg \times m\ s^{-1}$

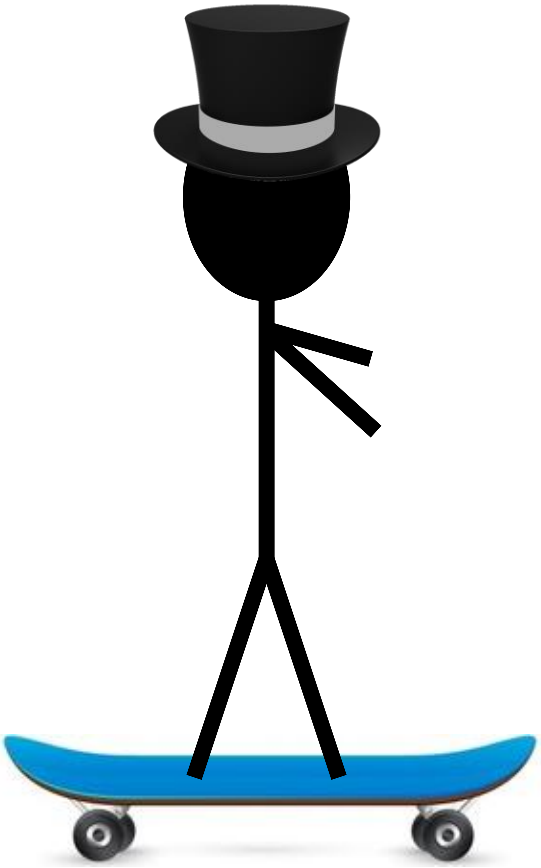
IB Physics Data Booklet

Sub-topic 2.4 – Momentum and impulse
$p = mv$ $F = \frac{\Delta p}{\Delta t}$ $E_K = \frac{p^2}{2m}$ $\text{Impulse} = F\Delta t = \Delta p$

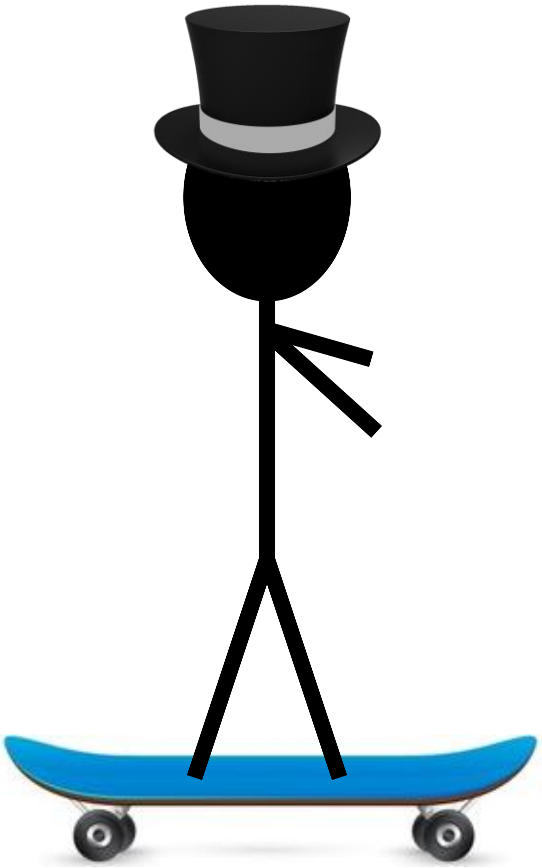
Explosion



Hit and Bounce

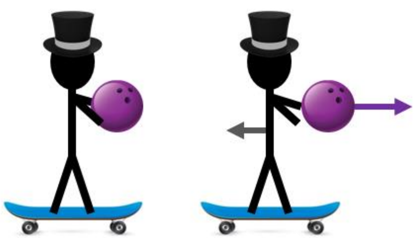


Hit and Stick

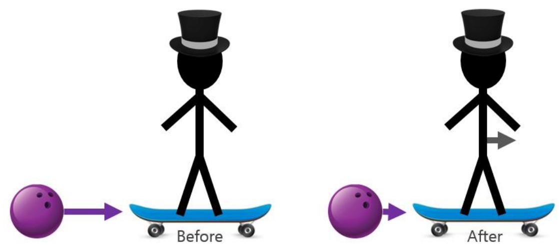


Conservation of Momentum

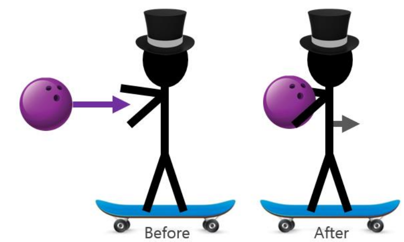
The total momentum of a system is constant



"Explosion"



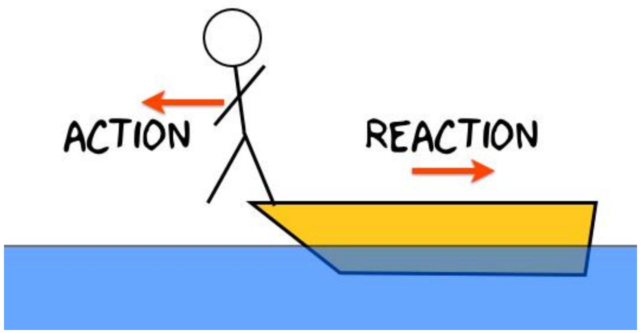
"Hit and Bounce"

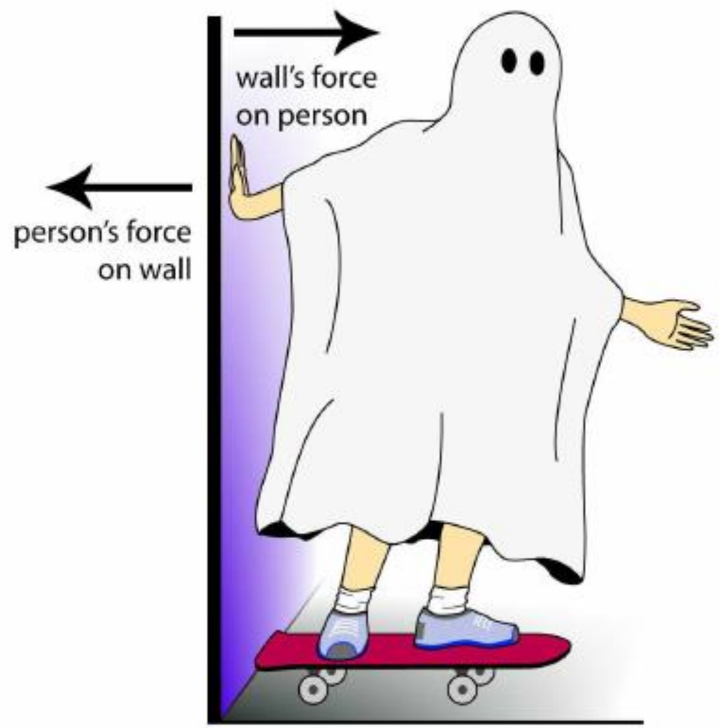


"Hit and Stick"

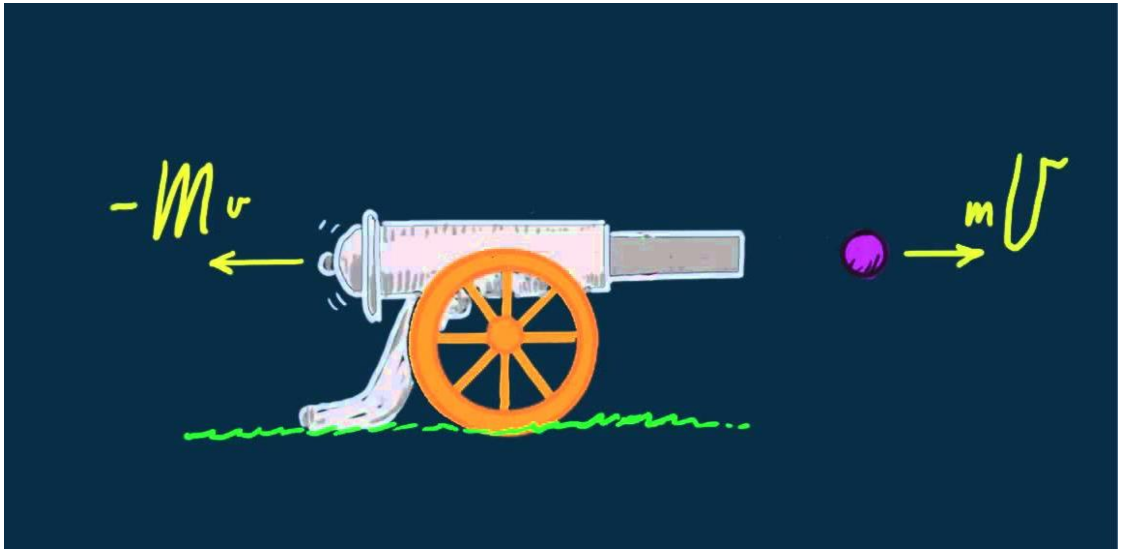
Newton's Third Law

For every action, there is an equal and opposite reaction





Conservation of Momentum



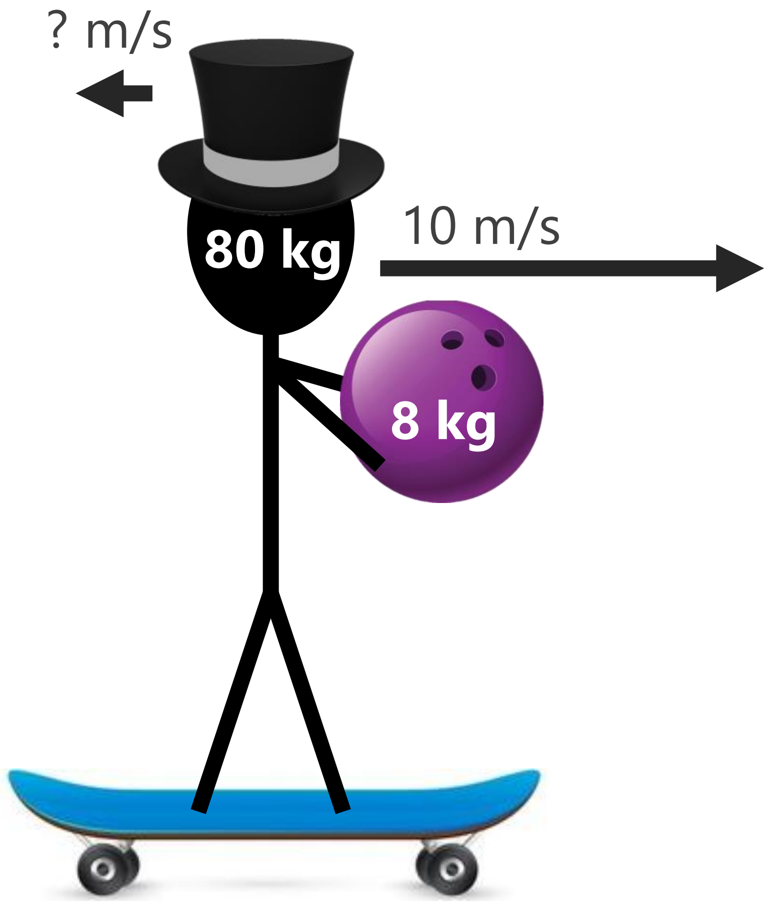
When a cannonball is fired out of a cannon, there is a recoil…

Equal and Opposite…

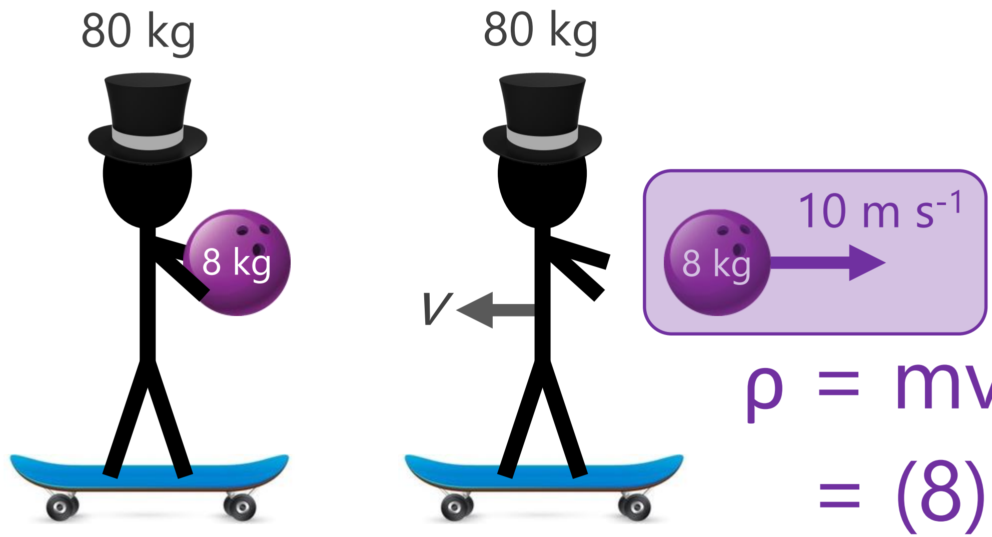
More mass → Less velocity

Less mass → More velocity

Explosion



Explosion



$$\rho = mv$$
$$= (8)(10)$$
$$= 80 \text{ kg m s}^{-1}$$

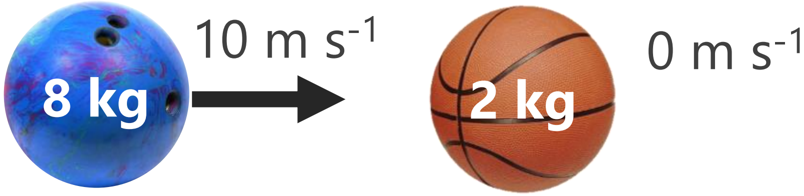
$$mv = mv$$
$$(80)(v) = (8)(10)$$

$v = 1 \text{ m s}^{-1}$

Hit and Bounce #1

2 m/s

Hit and Bounce #1



Before | After

$$(8)(10) + (2)(0) = (8)(2) + (2)(v)$$

$$80 + 0 = 16 + 2v$$

$v = 32\ m\ s^{-1}$

Hit and Bounce #2

Hit and Bounce #2

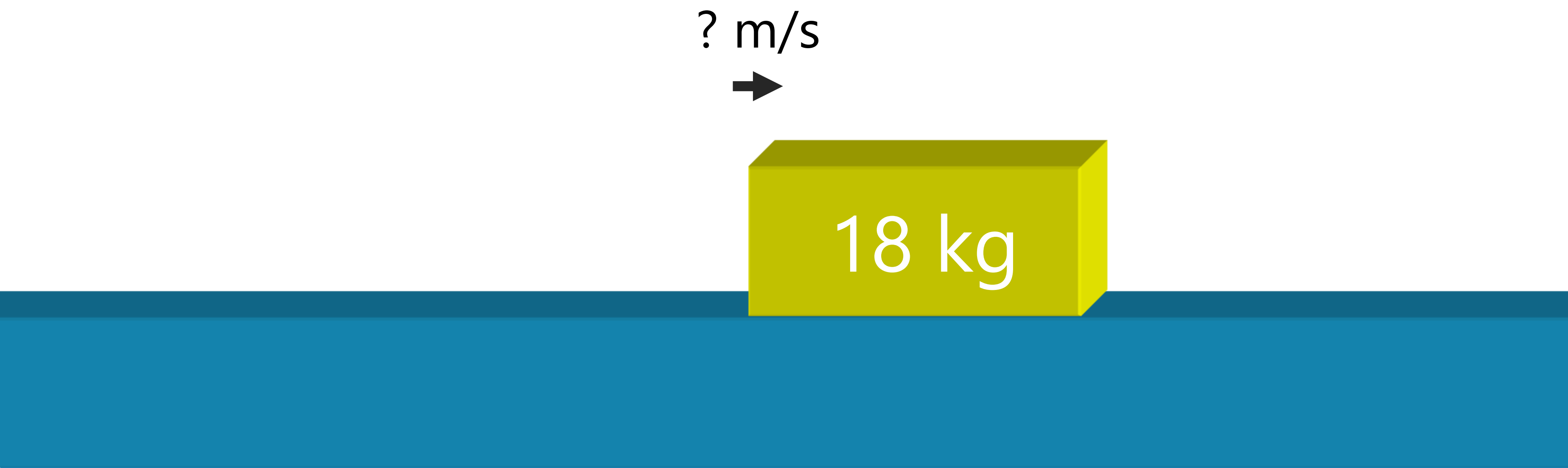
Before | After

$$(12)(8) + (18)(-4) = (12)(-5.5) + (18)(v)$$

$$96 + -72 = -66 + 18v$$

$$\mathbf{v = 5\ m\ s^{-1}}$$

Hit and Stick



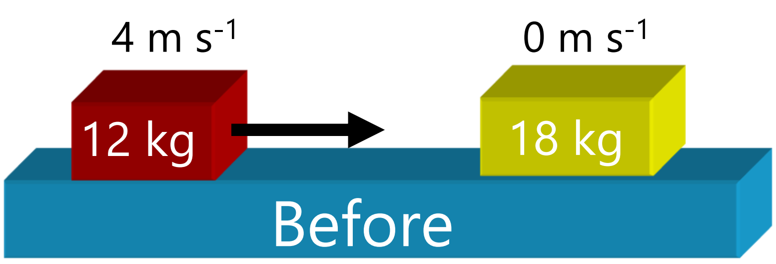
Hit and Stick

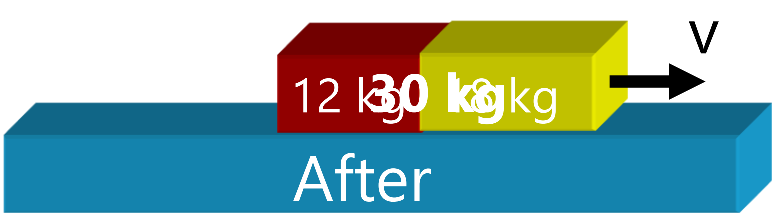
Before　　　　After

$$(12)(4) + (18)(0) = (30)(v)$$

$$96 + 0 = 30v$$

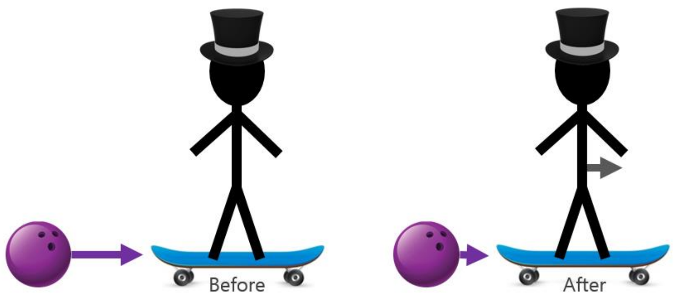
$$\mathbf{v = 1.6\ m\ s^{-1}}$$





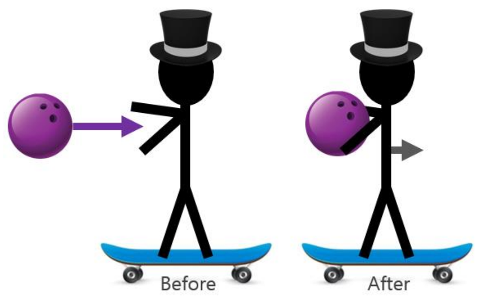
Elastic vs Inelastic

Elastic



Kinetic Energy is conserved

Inelastic



Kinetic Energy is **<u>not</u>** conserved

In both cases momentum is ALWAYS conserved

Try This...

A toy railcar of mass 2 kg travelling at 6 m s^{-1} collides with another railcar of mass 3 kg travelling at 4 m s^{-1} in the same direction. If after the collision the two trucks become joined together, what is their resulting velocity?

Before After

$$(2)(6) + (3)(4) = (2+3)(v)$$

$$12 + 12 = 5v$$

$$v = 4.8\ m\ s^{-1}$$

Compare the total Kinetic Energy before and after:

Before

$$\frac{1}{2}(2)(6)^2 + \frac{1}{2}(3)(4)^2$$

$$36 + 24$$

$$60\ \mathrm{J}$$

After

$$\frac{1}{2}(2+3)(4.8)^2$$

$$57.6\ \mathrm{J}$$

System loses **2.4 J** of Kinetic Energy so it is an inelastic collision

Lesson Takeaways

- ❑ I can define and calculate momentum
- ❑ I can use the conservation of momentum to solve for missing variables in linear collisions
- ❑ I can describe the process required for explosion, hit and bounce, and hit and stick scenarios
- ❑ I can describe the difference between elastic and non-elastic collisions
- ❑ I can calculate the amount of energy retained in a non-elastic collision